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SOLAR PHYSICS OBSERVATORY

TENTH ANNUAL REPORT OF THE DIRECTOR OF THE SOLAR PHYSICS OBSERVATORY TO THE SOLAR PHYSICS COMMITTEE

1922 APRIL 1—1923 MARCH 31

University of Cambridge

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Tenth Annual Report of the Director of the Solar Physics Observatory

The Vice-Chancellor begs leave to present to the Senate the following Report which the Solar Physics Committee have received from the Director of the Solar Physics Observatory:

The Report here presented relates to the year 1922 April 1 to 1923 March 31.

There are no changes to record in the Staff of the Observatory.

Mr Stratton continues research work on stellar spectra.

Mr R. Sekiguchi returned to Japan in October 1922.

Mr K. Sotome, Professor of Astronomy in the Imperial University, Tokyo, has come to the Observatory to gain experience in solar researches.

A. *Stellar Work.*

β Lyræ. The study of the spectrum of the well-known variable star *β Lyræ* has been continued by Mr Baxandall and Mr Stratton. The best of the series of 96 spectrograms lent by Dr H. D. Curtis, of the Allegheny Observatory, have been measured and have been utilized to throw light upon some of the peculiarities which had been noted in the spectrum at certain epochs in the star's light changes, in the series of plates obtained at Cambridge in 1921. In a similar way, the best of the South Kensington series have been re-measured, in order to gain further information concerning secular changes suspected in the period of one of the components of this complex stellar system.

The spectrum of *θ Aurigæ* has been assigned to the class Ao. Pec. It shows several absorption lines of unknown origin, which do not appear to have been recorded in any other celestial spectrum. Four spectrograms obtained in January 1923 have been measured by Mr Baxandall, who has found that changes in the spectrum indicate variable velocity with a range from + 24 km./sec. to + 49 km./sec. A longer series of photographs is needed to show whether the shift of the spectral lines is periodic or spasmodic. Even in the short series already obtained there is evidence that the intensities of some of the strange absorption lines vary considerably relatively to those of a set of lines of known origin in the star's spectrum. The changes recall the similar phenomena observed by Belopolsky in the spectrum of *α Canum Venaticorum.*

Lines of unknown origin in Celestial Spectra. In the spectra of various celestial bodies there is a residuum of lines which have hitherto defied identification with lines of known terrestrial spectra. A list of such lines was published in 1910, but since that date a number of the lines then not identified have been traced to their terrestrial equivalents, and fresh records have furnished additional lines of unknown origin. The previous list has accordingly been revised by Mr Baxandall; the lines are given in order of wave-length, and the particular celestial spectra in which the individual lines are found are indicated. The list has been communicated to the Royal Astronomical Society (*Monthly Notices,* **83**, 166). Mr Baxandall is preparing a list of the absorption bands, both of known and of unknown origin, in celestial spectra.

Problems relating to stellar atmospheres have been continued by Mr Milne. A paper on the temperature in the outer atmosphere of a star was communicated to the Royal Astronomical Society (*Monthly Notices,* **82**, 368). A memoir entitled "Radiative Equilibrium: the relation between the spectral energy curve of a star and the law of darkening of the disc towards the limb, with special reference to the effects of scattering and the solar spectrum" was communicated to the Royal Society (*Phil. Trans.* A **223**, 201). A memoir on the escape of molecules from an atmosphere with special reference to the boundary of a gaseous star was communicated to the Cambridge Philosophical Society (*Phil. Trans.* **22**, 483). A paper on the equilibrium of a rotating star was communicated to the Royal Astronomical Society (*Monthly Notices,* **83**, 118).

Further progress has been made in the construction of coarse diffraction gratings for use in an adaptation of Merton's method to the study of the distribution of energy in stellar spectra. The method of ruling broad lines in black ink on gelatine films on glass has been discarded on account of inadequate control of the width of the lines. Accurate gratings have been successfully made by a plan suggested by Mr Manning; tinfoil is laid on gelatine on glass and a succession of properly spaced cuts are made by a razor; and alternate strips of the foil are then pulled off and the gelatine in the clear spaces is dissolved away. Such gratings with special spacings are being used in the stellar prismatic spectrograph attached to the Huggins' telescope.

B. *Solar Work.*

Spectroheliograph. Photographs of the sun's disc in Calcium $K_{2,3,2}$ light have been obtained on 91 days (previous year 115) and photographs of prominences at the limb on 78 days (previous year 104). The photographs are taken on alternate days by Mr Butler and Mr Moss.

After the large disturbance of February—March 1922 the solar activity has continued to decrease until the end of 1922, when a large disturbance took place about December 20. This was followed by another interval in which the activity was very light. The number of spotless days increased from 31 in 1921 to more than 110 in 1922.

The 18-inch and 6-inch mirrors were dismounted on 27 March 1923 and remounted on 29 March 1923 after being resilvered.

The Director of the Kodaikanal Observatory has sent 320 spectroheliograms showing the sun's disc in $K_{2,3,2}$ light for the year 1922 January 1—December 31. Of the 45 days missed in the Kodaikanal records, there are Cambridge records for 6 days.

Photoheliograms. Daily photographs taken with the Dallmeyer photoheliograph at Dehra Dûn have been received as usual, and the negatives are stored at the Science Museum at South Kensington.

Study of Spectroheliograms. Investigation of the systematic distribution and forms of the calcium flocculi has been continued by Mr Butler, and results obtained from a study of those formations which exhibit elongation during the years 1915—1920 have been described in a paper communicated to the Royal Astronomical Society (*Monthly Notices,* **82**, 334). With the object of tracing the life history of these elongations, an examination has been made of all flocculi born on the visible hemisphere of the sun. The number of visible births is comparatively small; the majority of flocculi persist from limb to limb, that is, they have a life of at least 13—14 days. During the interval examined no certain cases of visible death have been observed. In nearly all flocculi observed from birth, the phenomenon of elongation has been detected soon after the birth of the flocculus.

Study of Records of Sunspots and Prominences. The examination of groups of sunspots is being continued by the Director and Mrs Beech, with special reference to distribution in longitude. Mr Moss has continued work on the distribution of prominences. From the manuscript records kindly supplied by the Director of the Kodaikanal Observatory, he has plotted the whole series of the Kodaikanal Observations from 1904 to 1922 on a uniform scale. The prominence activity in three special zones of latitude which had been noted in the earlier years, has again been found in the later years at a corresponding epoch in the sunspot cycle. The pronounced localization of the distribution in longitude is now being studied in detail.

Spectroscopic Determination of the Solar Rotation. More than 200 photographs for the determination of the solar rotation were secured during the summer and autumn by the Director and Mr Sekiguchi. They relate to observations at heliocentric latitudes ± 30°, ± 20°, ± 10° and 0° on the 'velocity chords' in the method devised by the Director (*Monthly Notices,* **81**, 115). Mr Sekiguchi after rendering valuable assistance in the observations and computations returned to Japan in October 1922: and Professor K. Sotome is now assisting in the work for the coming summer.

C. *Meteorological Physics.*

Atmospheric Electricity. Work on the electrical phenomena of thunderstorms and showers has been continued by Mr C. T. R. Wilson. Fewer observations were made than in previous years, partly on account of the infrequency of thunderstorms, partly because Mr Wilson was occupied mainly in his investigations of ionizing radiations.

Study of ionizing radiations by the cloud method. Most of the work has been concerned with the properties of β-rays and with the phenomena relating to their ejection from the atoms of a gas by X-rays. A few pictures of α-rays showing interesting features were obtained, and a short paper dealing with them was communicated to the Cambridge Philosophical Society (*Proceedings,* **31**, 405).

The study of β-ray tracks has related especially to the following points:

(*a*) *The primary and secondary ionizations* per centimetre of the track of a β-particle of which the range and velocity were approximately known: *i.e.,* (i) the number per cm. of atoms from which the primary β-particle has ejected an electron and (ii) the number of pairs of ions which the electrons thus ejected have set free.

(*b*) *Branching of β-ray tracks,* including the frequency of occurrence of branches exceeding a given range (corresponding to a given velocity of the ejected β-particle), and the resulting deflection of the primary β-ray.

(*c*) *Gradual bending of β-rays*, due to the systematic accumulation of small deflections.

(*d*) *Sudden bending*, due to a close approach of the β-particle to the nucleus of an atom.

The frequency of occurrence of deflections exceeding a right angle is in approximate agreement with Sir E. Rutherford's theory.

The results relating to ionization and branching are in most cases in approximate agreement with Sir J. J. Thomson's theory of ionization by β-rays, but there are differences and exceptions which cannot be attributed to experimental errors. The deviations from the simple theory may be accounted for by supposing that the nature of an encounter between a β-particle and an atomic electron may be influenced by radiation (X-rays or ordinary light) to which the atom is simultaneously exposed, and that the encounter may at the same time facilitate the absorption of the radiation. An important case is that in which the radiation has been excited by the β-particle itself in an atom which it has already traversed. Such processes would furnish a possible explanation of the curvature of β-ray tracks.

The principal results obtained in regard to the nature of the action of X-rays are the following:

1. X-radiations of short wave-length excite in air not only β-rays of which the velocity corresponds nearly to the frequency of the incident radiation but also additional β-rays of very short range which are ejected very nearly along the direction in which the incident X-radiation is travelling. The short-range β-rays (of which the energy is only a small fraction of that contained in a quantum of the primary radiation) are in all probability concerned in the phenomena which have led Barkla, Crowther and others to postulate the existence of J-radiations.

2. With regard to the initial direction of ejection of β-particles by X-rays, it is found that, in accordance with the partial polarisation discovered by Barkla in the X-radiation from an ordinary X-ray bulb, about 20 per cent. of the β-particles are ejected in the plane containing the original cathode-ray stream. A considerable proportion of the β-rays (about 20 to 30 per cent.) are ejected, so far as can be judged, exactly at right angles to the primary X-ray beam, *i.e.*, without any forward component. Of the rest the larger number have a forward component comparable with the lateral component, a few have a backward component of similar amount.

3. A considerable proportion of the β-ray tracks produced by X-rays occur in pairs or groups. Of these there are at least five easily distinguishable types. One of the β-rays of a pair is regarded as having been ejected from an atom by the direct action of the primary X-rays: the other by the resulting characteristic radiation from this atom, acting sometimes alone, but more often in combination with the primary or other radiations.

4. A number of photographs were obtained which showed that the two component β-rays of a pair had not been ejected simultaneously; there was in some cases a time interval of one or two thousandths of a second.

5. When a metal target is inserted in the primary beam of X-rays, there appear not only the tracks of β-rays ejected from atoms of the gas exposed to the primary beam, but also the tracks of β-particles ejected from the metal, and there are, in addition, outside the primary beam, tracks of other β-particles, due to the characteristic X-rays of the metal. The β-rays excited by characteristic radiations from targets of different metals have been used in obtaining the relation between range and velocity of the β-particle. In a few cases in which the radiation was cut down till no β-rays were ejected from the atoms of the gas by the primary X-rays, the tracks of only two β-particles appeared in the picture: one ejected from an atom of the gas by reason of the absorption of the characteristic radiation from the metal target, and one ejected from the target itself. The quantum of characteristic radiation which ejected the β-particle from the atom of the gas must have originated in the target from an atom which had lost a β-particle under the influence of the primary radiation. Since only one β-particle had been ejected from the target there appears to be no ambiguity as to the source of the quantum of characteristic radiation; and there is clearly none as to the point at which it is absorbed.

An account of the investigations, of which the above is a terse summary, has been prepared by Mr Wilson and is nearly ready for publication.

D. *Miscellaneous.*

Lectures. Lectures have been given by the Director in the Michaelmas Term 1922; by Mr Wilson on Atmospheric Electricity; and by Mr Milne on the Physics of Stellar Atmospheres.

Library. A number of valuable publications and reprints have been received in the course of the year, and the Director desires to record his grateful acknowledgments to the donors. A list of such donations is appended.

Painting. The domes of the Huggins' Telescopes and of the 3-foot Reflector were painted externally in October 1922.

H. F. NEWALL.

SOLAR PHYSICS OBSERVATORY,
12 *April* 1923.

The Director gratefully acknowledges the receipt of the following works, which have been presented to the Library of the Solar Physics Observatory:

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Batavia. Royal Magnetical and Meteorological Observatory. Observations made at Secondary Stations in Netherlands East Indies. Vol. viii. Batavia, 1920. Fol. Verhandlingen. Nos. 9—10. Batavia, 1922. 8vo. Regenwaarnemingen in Nederlandsch-Indië, 1919. Batavia, 1922. 8vo.	The Observatory.
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Kobe. The Memoirs of the Imperial Marine Observatory, Kobe, Japan. Vol. i. No. 1. Kobe, 1922. 8vo.	The Observatory.
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Cambridge: Printed at the University Press